CLAIMS

What is claimed is:

1. A method of acoustic signal reproduction in a mobile terminal including a plurality of loudspeakers accommodated inside a casing of the mobile terminal, the method of acoustic signal reproduction comprising:

Processing Step 1 of reducing spatial crosstalk generated, with respect to signals, inputted into the loudspeakers, in a space ranging from the loudspeakers to a control point; and

Processing Step 2 of reducing inter-loudspeaker crosstalk generated inside the casing, with respect to signals having gone through Processing Step 1.

2. A method of acoustic signal reproduction as recited in claim 1, wherein Processing Step 2 includes a summing step to Step-1-processed signals going into a one of the loudspeakers a reduction signal for reducing sounds inside the casing leaking out from another of the loudspeakers into the one of the loudspeakers.

3. A method of acoustic signal reproduction as recited in claim 2, wherein the reduction signal is generated by processing signals having gone through Processing Step 1, into the other of the loudspeakers.

4. A method of acoustic signal reproduction as recited in claim 3, wherein the processing of the Step-1-processed signals going into the other of the loudspeakers is performed according to a characteristic obtained by:

dividing a transfer function for a driving signal, for driving the other of the loudspeakers, as altered by at least acoustic couplings until emitted from the one of the loudspeakers,

by a transfer function for a driving signal, for driving the one of the loudspeakers, as altered by at least amplifier/loudspeaker characteristics until emitted from the one of the loudspeakers; and reversing the arithmetic sign.

5. A method of acoustic signal reproduction as recited in claim 1, wherein Processing Step 2 includes:

a first in-casing direct processing step of processing Step-1-processed signals going into the one of the loudspeakers to obtain a direct component for the one of the loudspeakers;

a first in-casing crossover processing step of processing Step-1-processed signals going into the other of the loudspeakers to obtain a crossover component for the one of the loudspeakers;

a first summing step of summing together both post-processed signals to produce a driving signal for driving the one of the loudspeakers;

a second in-casing direct processing step of processing

Step-1-processed signals going into the other of the loudspeakers to obtain a direct component for the other of the loudspeakers;

a second in-casing crossover processing step of processing Step-1-processed signals going into the one of the loudspeakers to obtain a crossover component for the other of the loudspeakers; and

a second summing step of summing together both post-processed signals to produce a driving signal for driving the second loudspeakers.

6. A method of acoustic signal reproduction as recited in claim 5, wherein

the first in-casing direct processing step is a process according to a transfer function for the driving signal, for driving the other of the loudspeakers as altered by amplifier/loudspeaker characteristics until emitted from the other of the loudspeakers,

the first in-casing crossover processing step is a process according to a transfer function for the driving signal, for driving the other of the loudspeakers as altered by at least acoustic couplings characteristics until emitted from the one of loudspeakers,

the second in-casing direct processing step is a process according to a transfer function for the driving signal, for driving the one of loudspeakers as altered by amplifier/loudspeaker characteristics until emitted from the one of loudspeakers,

the second in-casing crossover processing step is a process according to a transfer function for the driving signal, for driving the

one of loudspeakers, as altered by at least acoustic couplings characteristics until emitted from the other of loudspeakers.

7. A method of acoustic signal reproduction as recited in claim 5, wherein Processing Step 2 includes a post-processing step further processing one of the summed signals so that loudspeaker's emission signals emitted from the one of the loudspeakers are made approximately coincident with the amplitude/phase of Pocessing-Step-1-processed signals to the one of the loudspeakers.

8. A method of acoustic signal reproduction as recited in claim 5, wherein Processing Step 2 includes a pre-processing step processing, posterior to Processing Step 1 and prior to Processing Step 2, Processing-Step-1-processed signals to the one of the loudspeakers so that the-one-of-the-loudspeakers' emission signals are made approximately coincident with the amplitude/phase of Processing-Step-1-processed signals to the one of the loudspeakers.

9. A method for acoustic signal reproduction as recited in either one of claims 3 and 4, wherein processing Processing-Step-1-processed signals to the other of the loudspeakers is performed on a subband basis of the Processing-Step-1-processed signals to the other of the loudspeakers.

10. A method of acoustic signal reproduction as recited in claim 4, wherein processing Processing-Step-1-processed signals to

the other of the loudspeakers is performed according to a characteristic obtained by passing signals through a low-pass filter having the transfer function.

11. A method of acoustic signal reproduction as recited in either claim 3 or 4, wherein correlation between the Processing-Step-1-processed signals to the other of the loudspeakers and the Processing-Step-1-processed signals to the one loudspeaker is obtained on a frequency component basis, so that processing Processing-Step-1-processed signals to the other of the loudspeakers is performed according to the correlation.

12. A method of acoustic signal reproduction as recited in claims 3, wherein processing Processing-Step-1-processed signals to the other of the loudspeakers is performed according to a characteristic obtained by multiplying the Processing-Step-1-processed signals to the other of the loudspeakers, by a scalar value less than one, and reversing the arithmetic sign.

13. A method of acoustic signal reproduction as recited in claim 5, wherein one in-casing direct processing step and another in-casing direct processing step are approximately in common with one in-casing crossover processing step and another in-casing crossover processing step, respectively.

14. A mobile terminal including a plurality of loudspeakers

accommodated inside a casing of the mobile terminal, the mobile terminal, comprising a processing means 1 for reducing spatial crosstalk generated with respect to input signals to the loudspeakers, in a space ranging from the loudspeakers to a control point, and a processing means 2 for reducing inter-loudspeaker crosstalk being generated inside the casing, with respect to processing-means-1-processed signals.

15. A mobile terminal as recited in claim 14, wherein the processing means 2 sums together a reduction signal for reducing sounds leaking out, inside the casing, from another of the loudspeakers into a one of the loudspeakers, and processing-means-1-processed signals to the one of the loudspeakers.

16. A mobile terminal as recited in claim 15, wherein the reduction signal is generated by processing processing-means-1-processed signals to the other of the loudspeakers.

17. A mobile terminal as recited in claim 16, wherein processing processing-means-1-processed signals to the other of the loudspeakers is performed according to a characteristic obtained by:

dividing

a transfer function for the driving signal, for driving the other of the loudspeakers, as altered by acoustic couplings until

emitted from the one of the loudspeakers, by

a transfer function for the driving signal, for driving the one of the loudspeakers, as altered by at least amplifier/loudspeaker characteristics until emitted from the one of the loudspeakers; and

reversing the arithmetic sign.

18. A mobile terminal as recited in claim 14, wherein the processing means 2 includes:

a first in-casing direct processing means for processing processing-means-1-processed signals going into the one of the loudspeakers;

a first in-casing crossover processing means for processing processing-means-1-processed signals going into the other of the loudspeakers to obtain a crossover component for the one of the loudspeakers;

a first summing means for summing together both post-processed signals to produce a driving signal for driving the one of the loudspeakers;

a second in-casing direct processing means for processing processing-means-1-processed signals going into the other of the loudspeakers;

a second in-casing crossover processing means for processing processing-means-1-processed signals going into the one of the loudspeakers to obtain crossover components for the other of the loudspeakers; and

a second summing means for summing together both post-processed signals to produce a driving signal for driving a second loudspeaker.

19. A mobile terminal as recited in claim 18, wherein:

the first in-casing direct processing means performs processing according to a transfer function for a driving signal, for driving the other of the loudspeakers, as altered by at least either amplifier or loudspeaker characteristics until emitted from the other of the loudspeakers;

the first in-casing crossover processing means performs processing according to a transfer function for the driving signal, for driving the other of the loudspeakers, as altered by at least acoustic couplings characteristics until emitted from the one of the loudspeakers;

the second in-casing direct processing means performs processing according to a transfer function for a driving signal, for driving the one of the loudspeakers, as altered by amplifier or loudspeaker characteristics until emitted from the one of the loudspeakers; and

the second in-casing crossover processing means performs processing according to a transfer function for the driving signal, for driving the one of the loudspeakers, as altered by at least acoustic couplings characteristics until emitted from the other of the loudspeakers

20. A mobile terminal as recited in claim 18, further comprising a post-processing means for processing one summed signal so that loudspeaker's emission signals emitted from the one of the loudspeakers are made approximately coincident with the amplitude/phase of the processing-means-1-processed signals to the one of the loudspeakers.

21. A mobile terminal as recited in claim 18, further comprising a pre-processing means for processing, posterior to Processing Step 1 and prior to Processing Step 2, processing-means-1-processsed signals to the one of the loudspeakers so that the-one-of-loudspeakers' emission signals are made approximately coincident with the amplitude/phase of the processing-means-1-processed signals to the one of the loudspeakers.

22. A mobile terminal as recited in either one of claims 16 and 17, wherein processing processing-means-1-processed signals to the other of the loudspeakers is performed on a subband basis of the processing-means- 1-processed signals to the other of the loudspeakers.

23. A mobile terminal as recited in claim 17, wherein processing processing-means-1-processed signals to the other of the loudspeakers is performed according to a characteristic obtained by passing signals through a low-pass filter.

24. A mobile terminal as recited in either claim 16 or 17, wherein correlation between processing-means-1-processed signals to the other of the loudspeakers and processing-means-1-processed signals to the one of the loudspeakers is obtained on a frequency component basis, so that processing processing-means-1-processed signals to the other of the loudspeakers is performed according to the correlation.

25. A mobile terminal as recited in claim 16, wherein processing processing-means-1-processed signals to the other of the loudspeakers is performed according to a characteristic obtained by multiplying processing-means-1-processed signals to the other of the loudspeakers, by a scalar value less than one, and reversing the arithmetic sign.

26. A method for acoustic signal reproduction as recited in claim 18, wherein one in-casing direct processing means and another in-casing direct processing means, are in common with one in-casing crossover processing means, and another in-casing crossover processing means, respectively.

27. A method of acoustic signal reproduction in a mobile terminal including a quantity N of loudspeakers accommodated inside a casing of the mobile terminal, the acoustic-signal reproduction method characterized in that given that a loudspeaker's

emission signal S_i emitted from an i-th loudspeaker is expressed by the following equation, using a matrix H having a transfer function H_{ij} for a driving signal S_{di}, for driving the i-th loudspeaker, as altered by at least in-casing acoustic couplings until emitted from a j-th loudspeaker, and a transfer function H_{ii} for a driving signal, for driving the i-th loudspeaker, as altered by at least either amplifier or loudspeaker characteristics until emitted from the i-th loudspeaker,

Equation 1

$$\begin{bmatrix} S_1 \\ S_2 \\ \cdots \\ S_N \end{bmatrix} = \mathbf{HSd} = \begin{bmatrix} H_{11}, H_{21}, \cdots, H_{N1} \\ H_{12}, H_{22}, \cdots, H_{N2} \\ \cdots \\ H_{1N}, H_{2N}, \cdots, H_{NN} \end{bmatrix} \begin{bmatrix} Sd_1 \\ Sd_2 \\ \cdots \\ Sd_N \end{bmatrix}$$

then the driving signal S_{di} for the i-th loudspeaker is generated by performing, on a signal Y_i corresponding to the i-th loudspeaker, the signal having passed through a processing step of reducing in input signals spatial crosstalk generating in a space ranging from the loudspeakers to a control point, a process according to the following filter characteristic G based on cofactors Q_{ij} of components (i,j) of the matrix H.

Equation 2

$$\begin{bmatrix} Sd_1 \\ Sd_2 \\ \cdots \\ Sd_N \end{bmatrix} = \mathbf{G} \begin{bmatrix} Y_1 \\ Y_2 \\ \cdots \\ Y_N \end{bmatrix} \quad \text{where} \quad \mathbf{G} = a \begin{bmatrix} Q_{11}, Q_{12}, \cdots, Q_{1N} \\ Q_{21}, Q_{22}, \cdots, Q_{2N} \\ \cdots \\ Q_{N1}, Q_{N2}, \cdots, Q_{NN} \end{bmatrix}$$

28. A mobile terminal including a quantity N of

loudspeakers accommodated inside a casing of the mobile terminal, the mobile terminal configured so that given that a loudspeaker's emission signal S_i emitted from an i-th loudspeaker is expressed by the following equation, using a matrix H having a transfer function H_{ij} for a driving signal S_{di}, for driving the i-th loudspeaker, as altered by at least in-casing acoustic couplings until emitted from a j-th loudspeaker, and a transfer function H_{ii} for a driving signal, for driving the i-th loudspeaker, as altered by at least either amplifier or loudspeaker characteristics until emitted from the i-th loudspeaker,

Equation 3

$$\begin{bmatrix} S_1 \\ S_2 \\ \cdots \\ S_N \end{bmatrix} = \mathbf{HSd} = \begin{bmatrix} H_{11}, H_{21}, \cdots, H_{N1} \\ H_{12}, H_{22}, \cdots, H_{N2} \\ \cdots \\ H_{1N}, H_{2N}, \cdots, H_{NN} \end{bmatrix} \begin{bmatrix} Sd_1 \\ Sd_2 \\ \cdots \\ Sd_N \end{bmatrix}$$

then the driving signal S_{di} for the i-th loudspeaker is generated by performing, on a signal Y_i corresponding to the i-th loudspeaker, the signal having gone through a processing means for reducing in input signals spatial crosstalk generating in a space ranging from the loudspeakers to a control point, a process according to the following filter characteristic G based on cofactors Q_{ij} of components (i,j) of the matrix H.

Equation 4

$$\begin{bmatrix} Sd_1 \\ Sd_2 \\ \cdots \\ Sd_N \end{bmatrix} = \mathbf{G} \begin{bmatrix} Y_1 \\ Y_2 \\ \cdots \\ Y_N \end{bmatrix} \quad \text{where} \quad \mathbf{G} = a \begin{bmatrix} Q_{11}, Q_{12}, \cdots, Q_{1N} \\ Q_{21}, Q_{22}, \cdots, Q_{2N} \\ \cdots \\ Q_{N1}, Q_{N2}, \cdots, Q_{NN} \end{bmatrix}$$